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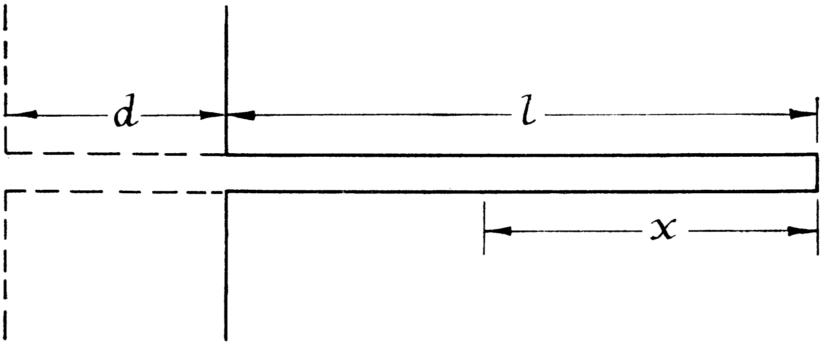
Here $2\pi/\sigma$ is the tidal period, t is the time, ϵ is a constant, l is the length of the estuary which has a depth h, and $c=(gh)^{\frac{1}{2}}$ is the velocity of a long wave in the estuary. Thus the ratio R of the tide at the section x to that in the sea is given by

$$R = \frac{\cos \sigma x/c}{\cos \sigma l/c}. \tag{3}$$

If then the estuary is extended seaward by a distance d, as indicated by broken lines in Figure 1, we have only to replace l in (3) by $(l+d)$. In normal circumstances this change will always lead to an increase in R.

As a numerical example, take the case $l=20$ miles, $x=10$ miles, a 12-hour tide giving $\sigma=2\pi/43200$ sec.$^{-1}$, and $h=30$ feet so that, with $g=32$ ft/sec.^{2}, $c=31$ ft/sec. It follows that $\sigma x/c=0{\cdot}248$, $\sigma l/c=0{\cdot}496$, and from (3) we obtain $R=1{\cdot}10$. The estuary being extended by 4 miles, $\sigma l/c$ becomes $0{\cdot}595$ and $R=1{\cdot}17$. Thus the increase in the tide at section x is about 6 per cent.



A more realistic shape can be examined on the same lines, though at the cost of introducing Bessel functions. This is the tapered form in which the depth and the breadth increase linearly with x, both being zero at $x=0$. Lamb (1932) proved that, the tide in the sea being again specified by (1), the value of R is now given by

$$R = \left(\frac{l}{x}\right)^{\frac{1}{2}} \frac{J_1(2k^{\frac{1}{2}}x^{\frac{1}{2}})}{J_1(2k^{\frac{1}{2}}l^{\frac{1}{2}})}, \tag{4}$$

where $k=\sigma^2 l/gh_0$, and h_0 is the depth at the mouth. The magnitude of the breadth is immaterial.

We will take the same values of x, l, σ, and g as before, with $h_0=30$ feet, and the result is $R=1{\cdot}07$. On adding 4 miles to l and keeping h_0 at 30 feet, we arrive at $R=1{\cdot}11$. Again there is a small but definite increase. It appears likely that the same will hold good for irregular shapes beyond the power of analysis, provided they do not exhibit abnormalities such as a cross-section diminishing with increasing x over part of the range. Thus a plausible explanation can be suggested for the observed increases in estuary tides without requiring that the level in the sea has risen also.

A. M. BINNIE

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ANCIENT ARMENIAN ROLLER-SKATES?

In a recent review of an Armenian atlas in this Journal (*Geogr. J.* **128**, 3 (1962): 336–7), I found occasion to refer, on Xenophon's evidence, to the use among the ancient Armenians of that 'modern' phenomenon, the drinking straw. It has now come to my notice that another 'first' in the world of discovery has been claimed for the Armenians, also on the evidence of a Classical author. In their absorbing work entitled *The ancient explorers*, first published in 1929 and now, in 1963, republished in a new edition in Pelican Books, Professors M. Cary and E. H. Warmington, in a passage on early exploration in the Armenian region, conjure up a delightful mental image in referring to 'the pleasant pastimes of tobogganing and roller-skating' practised by 'the natives of cold Caucasian and Armenian heights' (Pelican edition, p. 191). Strabo's account is rendered thus: 'The summits are untreadable in winter, but in summer the people go up them by binding under their feet shoes of raw ox-hide, flat out like timbrels, because of the snows and ice-covered stretches. And they go down, each lying with his load on a skin and sliding down, which is the custom also in Atropatene and on Mount Masius in Armenia; but there little wooden wheels with spikes are put under the people's shoes' (xi. 506). The ancient Armenian writers themselves make no mention of tobogganing on snow-covered slopes, but the Herodotus of Armenia, Moses of Khoren, does describe a method of descent adopted in the heights of Armenia which recalls Ammianus Marcellinus's account of the way in which the ancient inhabitants of Switzerland dealt with the problem of descending icy slopes. 'In these Cottian Alps', writes Ammianus, 'which begin at the town of Susa, there rises a lofty ridge, which scarcely anyone can cross without danger. For as one comes from Gaul it falls off with sheer incline, terrible to look at because of overhanging cliffs on either side, especially in the season of spring, when the ice melts and the snows thaw under the warmer breath of the wind; then over precipitous ravines on either side and chasms rendered treacherous through the accumulation of ice, men and animals descending with hesitating steps slide forward, and waggons as well. And the only expedient that has been devised to ward off destruction is this: they bind together a number of vehicles with heavy ropes and hold them back from behind with powerful efforts of men or oxen at barely a snail's pace; and so they roll down a little more safely' (xv. 10.3.4, tr. J. C. Rolfe, Loeb Classical Library). The vehicles in this case (*carpenta*) were wheeled, and in this respect the expedient described by Moses of Khoren differs. The event related in his *History of the Armenians* took place *ca.* A.D. 388 (it may be noted that Ammianus lived in and wrote of this period, and that it is possible that the Armenian author, dated variously as between the fifth and ninth centuries, knew his work, and this passage in particular; there is a fantastic element in Moses' *History*, which is thus to be treated with caution, and he may have drawn on Ammianus for the account which follows in order to colour his narrative). At this time a rebel group of nobles was fleeing with the treasure of Arshak III, king of Byzantine Armenia, to join the rival king Khosrov III in Persarmenia, hotly pursued by Arshak's men under the leadership of Samuel Mamikonian. Having crossed the Euphrates from the direction of Erzindjan, they entered the canton of Mananagh, a hilly region south-west of Erzerum bounded by Tauric mountains such as Mamakhatun, Miriam Dagh and Zerdige Dagh in the north, Khatch Dagh in the south and Karakaya Dagh in the east. They took refuge in a naturally fortified cave, the only approach to which lay down a narrow and steep slope. 'In front of the entrance to the cave', writes Moses in a difficult passage (and he is not in general noted for the clarity of his style), 'there stood a massive, vertical peak, from the top of which an icy grotto, surmounted by an overhang, looked down into the depths of the valley below. Whatever (stones) broke loose rushed down in a land-slide of fearful violence, rolling over and over and not ceasing (until they reached the bottom of the valley); there was no foot-hold anywhere. The difficulty of the terrain filled Samuel with doubt and uncertainty; but Arshak, having been informed (of his predicament), commanded them [*or* Arshak having been informed (of the predicament) he (Samuel) commanded (his men)] to construct a box reinforced with iron, to place brave fighting-men inside it, and to let it down on the end of wire ropes. No one was hurt at all', continues Moses, suddenly and anticlimactically concerned with scratches as well as sudden death, 'because the box very successfully kept off the brambles' (iii. 45). This method is presented by the ancient author as an isolated *ad hoc* expedient, but, especially in view of what Classical writers have to say about the practices of the Armenian and Caucasian mountain-dwellers and which Cary and Warmington hold, somewhat hastily perhaps, to be 'the most interesting thing which the explorers came across' in that part of the world, it possibly had a more general application than he suggests. According to the more likely rendering of the passage above, Arshak seemed to know what should be done in order to descend such a slope without actually having seen it. And how, one must wonder, did the fugitives get down to the cave in the first place?

Another method of progression in difficult conditions is mentioned by Xenophon, who shows (*Anabasis*, IV. 5) that in 400 B.C. the Armenians tied small bags round the hooves of their horses and pack animals when crossing deep snow, as they were liable to sink up to their bellies without them. One can thus reliably credit the Armenians with toboggans, a funicular and snow-boots. Roller-skates, however, are quite a different matter. The phrase in question reads in Strabo's Greek: *ἐνταῦθα δὲ καὶ τροχίσκοι ξύλινοι κεντρωτοὶ τοῖς πέλμασιν ὑποτίθενται. τροχίσκοι ξύλινοι κεντρωτοί* is evidently to be translated as 'small discs of wood with spikes through them', for even the primitive noun *τροχός*, in addition to its basic meaning of 'wheel', can mean 'disc', as in *τ. ἡλίου* 'sun's disc'. Roller-skates not being especially suitable for mountaineering even if furnished with spikes, these discs were obviously fastened flat under the soles of the shoes in order to retard, and not accelerate, one's rate of progress down the slope, and to give one a foothold going up. As a compensation, however, the Armenians can at least claim to be the first people recorded as wearing what in the world of sport, I believe, are known as 'spikes'.

The word *τροχίσκοι* which Strabo chose to describe this specialized footwear is of interest, if only coincidentally, in view of the existence of Armenian *trex* 'calceamentum caliga, calceus rusticus', 'a shoe with laces' (*NBHL*), 'sandal, wooden shoe, clog' (Bedrossian), a word first attested in the works of Nerses Shnorhali and Mxithar Gosh, therefore not before the twelfth century A.D. Apart from Bedrossian's definition, probably inexact, there is no evidence that this footwear was made of wood. The ordinary Armenian *trex*, consisting of an oval piece of leather (goatskin or oxhide) furnished with leather laces, and when attached to the foot leaving the instep bare, corresponds to Hesychius' description of Greek *τροχάς*, in pl., as *σανδάλια ἀπὸ αἰγείου δέρματος* 'sandals made of goatskin' (in sg., 'gallicula'—*Gloss*, Liddell and Scott). Armenian *trex* is surely connected with *τροχάς*, and this with *τροχός*. The Greek words, deriving from Indo-European **dhro-gh-*, from the base **dhre-gh* (*τρέχω*), have already been reliably connected with Armenian *durg-n* 'potter's wheel' from **drug-n* from I.E. **dhrō-gh-* (see Hübschmann, *AG*, p. 440). Armenian *trex*, on the other hand, would derive from I.E. **dre-kh-*. Reviewing *τρέχω* (from **dhre-gh-*), Gothic *thragyan* 'run' (from **tre-q-*), Irish *traig* 'foot', Serbo-Croat *trêg* 'footprint' (from **tre-gh-*), Boisacq (*Dictionnaire étymologique de la langue grecque*) observed in the Indo-European root 'alternances indo-européennes tant à l'initiale (*t-*, *dh-*) qu'à la finale'. In this context a form **dre-kh-* of the same root would not be impossible, and *durgn* and *trex* would then be doublets deriving from two dialectical variants of the same Indo-European root, although such a phenomenon must be rare. Arm. *trex* could, however, only with greater difficulty be explained as a distorted loan from the rare Greek word *τροχάς*, and is much more likely to be a cognate. Semasiologically, there is no serious objection to assuming the words mentioned above to derive from the same root; one might compare such words as English *runner* (on a sledge), *slipper*, and Russian *begun* 'runner, top millstone'.

As a cultural object, the Armenian *trex* corresponds to the Turkish *çarĭk*, which it is tempting, in view of what has been said above, to connect with *çark* 'wheel', from Persian *čarx*. In Georgian the shoe is called a *k'alamani*, referred to by A. Byhan, in the plural, as *kalambnebi* 'sandales munies de longs lacets de cuir' (*La civilisation caucasienne*, p. 41). The observation of a former secretary of the R.G.S., D. W. Freshfield, to the effect that 'no Caucasian ever wears anything but leather sandals stuffed with dry grass' (*The exploration of the Caucasus*, 1896, vol. 1, p. 121) adds an interesting detail, and its general accuracy is corroborated by a phrase quoted in Malxaseantz's Armenian Dictionary: 'villagers usually wear *trex-s*'. The latter also lists the modern Armenian expression 'to flee with one *trex* on', i.e. 'to move off as fast as possible'. This phrase might perhaps describe the flight of the rebel nobles mentioned above, who, it might be noted, got away. C. J. F. Dowsett

THE FIRST AMERICANS AT MOCHA

The launching of Winthrop's *Blessing of the Bay* at Medford in 1631 marks the beginning of serious shipbuilding enterprise in America. The Navigation Act of 1651 gave added impetus to shipbuilding but forty years later Imperial control of commerce was tightened. After the Peace of Utrecht of 1713 prosperity returned but by 1787 less than twenty ships were built annually in Massachusetts. American voyages to the East between 1784 and 1789, however, produced a great demand for new ships, particularly in Salem, and Enos Briggs, Ebenezer Mann and Retire Beckett manufactured most of them. A large surplus of tea in Boston and Salem in 1790 and British depredations on American commerce in 1793 and 1794 hastened the search for new markets. The Red Sea coffee trade was one of these.

Beckett built the *Recovery*, 284 tons, in 1794 for Elias Haskett Derby, the great Salem owner. Captain Joseph Ropes took her to Calcutta in 1796 and to Mocha in 1798 after visiting Mauritius. As the first American vessel to call at Mocha she beat the *Enterprise* (Captain Richard Cleveland) which left Salem in 1797 bound for Mocha but was ordered to return home from Le Havre. At Mocha, Ropes did little trade and, after visiting Calcutta, returned to Salem loaded with sugar. He commanded, in 1812, the privateer *America*. Later the *Recovery* went to Calcutta via Hamburg under command of Captain Stephen Phillips. Now owned by Colonel Derby and commanded by Captain Luther Dana she returned from Mocha in 1801 with 326,000 lbs of coffee and charts of the roads for a Salem syndicate. The *Ulyssees* of Salem was the next American vessel to call. Rumour had it in Salem that the *Recovery* and the *Ulyssees* were the only American ships admitted by the Imam to the Mocha roads. Unfortunately the pioneering of the *Ulyssees* was short-lived; she was wrecked off Cape Cod in February 1802. Two years later attempts were made to establish a factory and American captains obtained permission to fly their flag on their rented house which served as warehousing and shore living quarters. Unpopularity with English merchants, who saw Americans ruining the coffee trade by paying high prices, was aggravated by American insistence on jettisoning ballast in the roads. Complaints to the governor by Dr. Pringle, the English Resident, produced little redress. The Imam had not then recognized the Americans as a nation but visiting American merchants had promised to bring him presents and to establish a factory. Between 1800 and 1810 American activity at Mocha intensified. Captain Dutton Williams commanding the *Nancy* and William Leech with the *Suwarow* both put into Mauritius after successful visits to Mocha in October 1804. The next year, the *Cora* (Captain George Billfort) and the *Hebee* (Captain James Pearsall) visited the port, the *Hebee* returning in the summer of 1807 in company with the *Lion* (Captain Robert Stanley). The *Margaret*, built in Salem in 1800 by Beckett for John Derby and Benjamin Pickman, was also at Mocha in 1804 under command of Captain Henry Elkins in company with another Beckett ship the *America* (Captain Benjamin Crowninshield), ten guns, and nine others from Salem and Baltimore. On 25 May 1805, probably bearing presents for the Imam and equipment to establish a factory, Captain Daniel Bray Jnr. headed the Salem barque *Mary* for Mocha. Relations were however strained by an unpleasant incident in the next year. William Orne's Salem ship *Essex* (Captain Joseph Orne) augmented her crew at Mocha with some thirty Arabs who later turned pirate. Off Kamaran she was boarded, the crew murdered and the ship burned. Captain David Seton, the English Resident at Muscat, took the *Mornington* and *Ternate* to Mocha in an abortive search for the pirates.

Notwithstanding restrictions imposed by Jefferson's Embargo Act of 1807, the *Margaret* again brought coffee from Mocha into Salem in October 1807 and the *Franklin* loaded 532,370 lbs in 1808 for Joseph Peabody. In March 1809 oriental trade was formally resumed and in that year 2,000,000 pounds of coffee were imported from